Orthotic

Field of the Invention

The present invention relates to orthotic inserts or insoles for, for example, running or other athletic shoes, and more particularly to such devices that provide protective cushioning in the heel and metatarsal-phalangeal areas of the foot, while enhancing the athletes performance by providing lift or propulsion as the foot is lifted from an athletic surface during athletic activity.

Background of the Invention

The design, construction and sale of athletic and other footwear that demonstrates improved comfort has attained very significant commercial proportions. Consequently, a great deal of effort has been expended to provide a more comfortable shoe particularly for runners and other athletes whose feet undergo extreme pressure during athletic activities. Thus, a very large number of insert and/or insole structures have been proposed to provide such added comfort and foot protection, particularly in the metatarsal-phalangeal and heel areas of the foot.

Among the proposed improvements is that disclosed in U.S. Patent No. 5,542,196 to Kantro issued August 6, 1996 that describes a innersole of two different materials one harder than the other, with the softer material located under the Ball

and heel portion of the foot. While such a device provides one solution to the enhanced comfort problem, the device is multi-layered and fairly difficult to fabricate and therefore reasonably costly to produce. Its benefits are derived from differences in material properties. Additionally, with these differences in material properties, being one harder than the other, carry the potential for problems with wear characteristics, disassociation, deterioration at different rates, delamination, and segmental migration.

It is well recognized by those familiar with the biomechanics of the human foot and ankle that in walking and running the foot passes through a cycle comprised of a number of phases often referred to as the gait cycle. One method of defining some of the portions of these phases as they relate specifically to the foot, is that the foot is "pronated" or more simply, relaxed, during that phase of the gait cycle when it about to and actually strikes the ground and assumes the foot-flat position, while it is defined as "supinated" or, more simply stiffened as it prepares to leave the ground for the toe-off position or the start of the next cycle. The reasons for this are fairly simple, intuitive and well understood. The foot is pronated as it strikes the ground so that it can adapt and adjust to the surface with which it is becoming engaged. The foot is supinated as it leaves the ground in the toe-off position so as to provide a levered platform to generate the drive or lift necessary to propel or launch the body forward toward the next step.

As evidenced by the large number of "new and improved" athletic shoes introduced each year that propose to improve running, jumping or other athletic performance, there have been numerous prior art methods proposed for enhancing athletic shoes to take advantage of the above-described foot positions and conditions to enhance athletic performance.

For example, U.S. Patent No. 4,858,338 to Schmid, issued 8/22/89 describes a shoe sole insert made of an elastic material that purports to absorb and store energy as it is bent at the heel strike and midstance portions of the gait cycle and returns that energy to the wearer during and immediately following the toe-off portion of the gait cycle.

U.S. Patent No. 4,222,182 to Sears, issued September 16, 1980 suggests the incorporation of a transverse spring steel member to accomplish absorption and regeneration of the energy acquired during the heel strike and midstance portions of the gait cycle.

U.S. Patent No. 5,191,727 issued March 9, 1993 to Barry et al. describes a propulsion plate for incorporation into footwear that includes a specially configured spring plate that extends beneath the medial but not the lateral portion of the heel, through the arch region, to and beneath the metatarsal head region and toe region to reduce the force spike at heel impact.

U.S. [1]Patent No. 5,052,130 to Barry et al., issued October 1, 1991 describes an athletic shoe spring plate in combination with a viscoelastic midsole, the spring plate being fabricated of multiple layers of carbon fiber/polymer composite and having upturned heel and toe extremities.

While these and other similar proposed improvements have advanced the state of the art in foot comfort and performance for athletes, there remains a need for further improvements in foot comfort particularly for athletes as they continue to push their capabilities toward ever higher objectives, i.e. longer distances, higher jumps etc. and none of these prior art references alone or in combination suggests the unique structure described in this application that provides both comfort and the capture and return of energy generated naturally during the gait cycle.

Objects of the Invention

It is therefore the object of the present invention to create a semi-rigid kinetic energy storage device to enhance locomotion with relief areas that confer additional effects

1) **provide comfort across the metatarsalphalangeal joints (MTP), or ball of the foot, via its depressable nature while having the necessary rigidity to provide an upwardly pressure as to maintain the overall energy storage capacity of the device. This is performed through a series of one or more prongs arranged in a variety of directions, all of which accomplish the said effect. These directions**

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include forward pointing and/or rearward pointing and/or sideward pointing and/or downward pointing and/or upward pointing.

2) The prongs when depressed apply a downward ground reaction force which a) resists bending, b) provide a spring-like effect to soften one's impact upon weight-bearing, and c) provide a push-off spring effect for propulsion of the foot.

Summary of the Invention

These and other objects of the present invention are provided by an orthotic device comprising a generally foot shaped body to include relief areas that separate from the main body of the device at areas that underlie the metatarsalphalangeal aspect of the foot and optionally, the heel of the foot. These relief areas interdigitate or disconnect to varying degrees from the main body of the device. These relief areas are cut, attached, or otherwise provided in the indicated areas of the orthotic device to define resilient segments which are depressed by the application of the weight of a user and return to their original configuration upon removal of some or all that weight, as is accomplished in the normal gait cycle of walking or running.

Description of the Drawings

Figure 1 is a bottom plan view of the orthotic device of the present invention.

Figure 2 is a partially phantom top plan view of the orthotic device of the present invention.

Figure 3 is a cross-sectional view of an athletic shoe incorporating the orthotic device of the present invention along the line B-B of Figure 1.

Figure 4 is a cross-sectional view of an alternative preferred embodiment of the orthotic device of the present invention.

Figure 5 is a cross-sectional view of yet another alternative preferred embodiment of the orthotic device of the present invention.

Detailed Description

The present invention provides an orthotic device comprising a generally foot shaped body including interdigitated portions that underlie the metatarsalphalangeal aspect of the foot, and optionally the heel of the foot. These interdigitated portions are provided by relieved areas having prongs or fingers cut or otherwise provided in the indicated areas of the orthotic device. The fingers or

prongs are depressed upon the application of the user's weight and resiliently rebound to their original configuration upon removal of all or a portion of that weight. It is a characteristic of the interdigitated areas that they impart both a cushioning effect upon the application of pressure and a propulsive effect upon the removal of pressure as the foot enters and immediately as it leaves the toe-off segment of the gait cycle.

Referring now to Figure 1, orthotic 10 of the present invention comprises generally foot sole shaped base 12 having interdigitated areas 14, in the area of the ball of the foot or the forward area of base 12, i.e. the metatarsalphalangeal aspect, and 16 in the area of the heel of base 12. Optionally, reliefs or cut-outs 18 may be provided in the area of the arch to lighten orthotic 10, decrease stiffness and provide additional foot ventilation, or, conversely, reinforced to increase the stiffness of orthotic 10.

Area 14 underlies the metatarsalphalangeal aspect of the foot, while area 16 is located to underlie the heel of the foot. As the weight bearing foot moves from the foot-flat to toe-off portion of the gait cycle, area 14 yields through depression of the interdigitated prongs or fingers 20A through 20F, energy is stored by depression or compression of prongs 20A through 20F and released and imparted to the foot of the user as the foot moves through the gait cycle into the toe-off position. Prongs or interdigitated fingers 22A through 22F in area 16 serve to cushion and relieve contact pressure and store energy during the heel strike portion of the gait cycle,

while releasing this stored energy in the form of proplulsive energy as the foot enters later aspects of the gait cycle.

As best seen in Figure 1 and also Figure 2 that shows a cross-section of orthotic device 10 incorporated into the sole 24 an athletic shoe 26, interdigitated areas 14 and 16 are comprised of relieved areas 28 and 30 in the bottom of orthotic device 10 whose shapes, in this example, define the shape of prongs or fingers 20A through 20F and 22A through 22F. Any number and shape of prongs may be substituted that achieves the desired end of depressability and spring-like resistance to the structure. In the case where orthotic device 10 is supplied as a separate insert rather than part of the shoe, relieved areas 28 and 30 are cut or otherwise formed in the bottom of orthotic device 10. Generally, the larger the cut out area 28, the more relief and less resistance the device will impart.

Thickness 32 may vary from less than a millimeter to several centimeters or more. Thickness 32 is limited only by the comfort of the wearer and/or the thickness of the shoe sole depending upon the weight of the user and the design of areas 14 and 16. Of course, areas 14 and 16 can be relieved to differing levels in the same orthotic device 10, if desired. The thickness 32 of the orthotic 10 need not be consistent. The thickness and/or material nature of areas 14 and 16 may vary from that of the overall orthotic 10. As an insert, orthotic device 10 may include a separate padded or resilient surface (not shown) on top surface 36 as is conventional practice in the design of orthotic devices of similar types. In such a case the

separate resilient surface would be considered an integral part of orthotic device 10 for purposes of calculating the degree of acceptable relief.

It should be noted that the configuration of interdigitated areas 14 and 16 can be varied widely from that shown in the attached figures. For example, prongs or fingers 20A through 20F could be oriented transversely to the length of the shoe rather than longitudinally as shown in the attached figures. Similarly, prongs or fingers 22A through 22H could define an overall oval, generally rectangular or any other suitable shape so long as appropriate energy absorption, storage and release is obtained from the configuration chosen and foot comfort is not sacrificed. Similarly, a larger or smaller number of fingers or prongs can be included by the simple expedient of changing the shape of relieved areas 28 and 30. The prongs need not have symmetrical interdigitations, for instance, shortening one of the two opposing sets of prongs would a lesson degree of the desired effect.

Although orthotic device 10 may comprise a substantially flat member as depicted in Figures 1 and 2, this and all described alternative embodiments thereof, may also incorporate an arch 34 at the appropriate location therein to provide the generally desirable arch support as shown in Figure 3, as well as other curves or structural reinforcements. Orthotic device 10 can be supplied in varying arch widths and depths when provided as an insole or insert and can be incorporated into the sole of the shoe when provided as an integral part thereof. Any and all such modifications are clearly intended to be within the scope of the appended claims.

Additionally, areas 14 and 16 may be flat, i.e., follow the contour of the device as depicted in Figure 3, or may be curved or levered downward or upward to enhance the fundamental effect of prong compression as shown in Figure 4 . This configuration is consistent with both the comfort and propulsive objectives of the device.

Referring now to Figure 4, while in the description of previous embodiments in connection with Figures 1-3 orthotic device 10 has been shown as incorporating essentially flat interdigitated prongs or fingers, according to the preferred embodiment depicted in Figure 4, interdigitated prongs or fingers 20A-20F and 22A-22F are formed bent or slanted downward such that they project below lower surface 12A of orthotic device 10. With this configuration, intedigitized prongs or fingers 20A-20F and 22A-22F provide additional resistance to downward pressure thereon and thus store more energy as the foot compresses them and release this increase energy as the foot moves to release the pressure thereon.

This enhanced energy storage and release can be further enhanced with the structure depicted in Figure 5 wherein fulcrums 26 and 28 and 30 and 32 have been introduced between interdigitated prongs or fingers 20A-20F and 22A-22F at the bases thereof and lower surface 12A of orthotic device 10. The introduction of fulcrums 26, 28, 30 and 32 further increase the resistance of interdigitated fingers or prongs 20A-20F and 22A-22F to deflection as the foot moves downward resulting in

an increase the amount of energy stored by this action and allowing the release of this additional energy as the foot pushes off the ground. Fulcrums 26, 28, 30 and 32 may comprise simply a thickening of the material of orthotic device 10 at the appropriate points or the introduction of a fine metal or other material rod at this point to provide the appropriate fulcrum. Whatever mechanism is used, caution must me exercised not to compromise the comfort of orthotic 10 by the introduction of fulcrums as described and shown.

The materials of construction of orthotic device 10 are similarly also largely a matter of design choice subject to certain inherent and fundamental requirements. The material(s) of construction should be one(s) that demonstrate strong tendencies to retain their original shape and when deflected or deformed tend to return to that original shape. Such materials will inherently resist bending moments and incorporate significant spring-like capabilities that provide the energy storage and release properties necessary to achieve the advantageous performance desired when deflected by the weight of the wearer. High tensile strength materials having moduli of elasticity above about $32X10^6$lb/in^2 are suitable for this application. The material is also preferably lightweight so as not to add to the athletes lifting burden during strenuous activity. Suitable materials include carbon and graphitic materials of the types used in prior art orthotic devices including carbon-carbon, and polymer-matrix carbon composites and the like as well as spring steel and fiberglass materials demonstrating these properties. Graphite fiber materials possessing light weight, high tensile strength, high modulus of elasticity and that are generally easily

fabricated are specifically preferred in such applications. The selection of such materials is well within the skill of the art once the design and functioning characteristics of orthotic device 10 and know and understood. Specific material selection, orthotic device thickness 32 and the depth dimensions of relieved areas 28 and 30 can and ideally are custom matched to the wearer depending upon his or her foot size and body weight for optimum performance.

Orthotic device 10 is preferably, of course of a size to cover substantially the entire bottom of the wearer's foot so as to provide maximum efficiency in use.

As the invention has been described, it will be apparent to those skilled in the art that the same can be varied in many ways without departing from the spirit and scope of the invention. Any and all such modifications are intended to be included within the scope of the appended claims.